

## Solar Thermal Propulsion Thrusters and Cryogenic Fluid Management

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A number of technologies must mature before full-scale development of the solar thermal propulsion concept can be undertaken. These include the absorber/thruster and the subcritical liquid-hydrogen storage/feed system. Basically, the solar propulsion concept involves focusing sunlight on a high-temperature absorber that heats hydrogen to 2,500 Kelvin and expels it from a nozzle for thrust in the 4.4- to 44.0-Newton range at high specific impulse (800 to 900 seconds). The MSFC effort consists of three basic elements: (1) development of absorber/thruster fabrication and assembly techniques, (2) development of an MSFC solar test facility, and (3) testing of a cryogenic fluid management subsystem. Activities and accomplishments for each of the three elements are summarized below. Reference figures 63 and 64.

**Absorber/thruster:** High-temperature absorber/thruster operation presents significant technology challenges involving heat transfer and materials selection and design. As presently envisioned, the absorber/thruster will be constructed primarily of a tungsten/rhenium-alloy inner and outer shell surrounded by a carbon foam or graphite insulation. The gaseous hydrogen will flow through the passage between two shells, absorb the energy focused into the inside cavity,

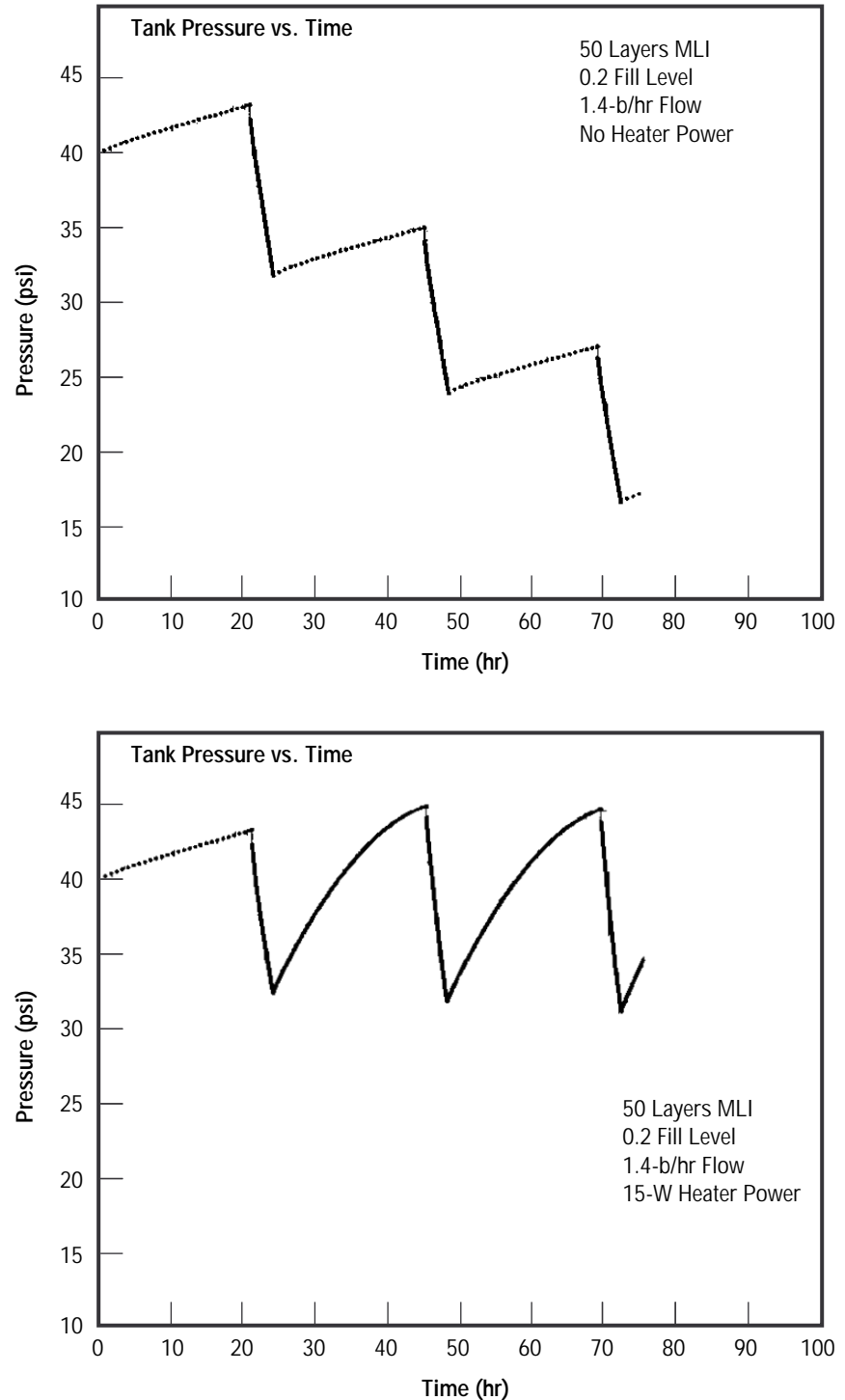


FIGURE 63.—Predicted pressures with vent system feeding the thruster.

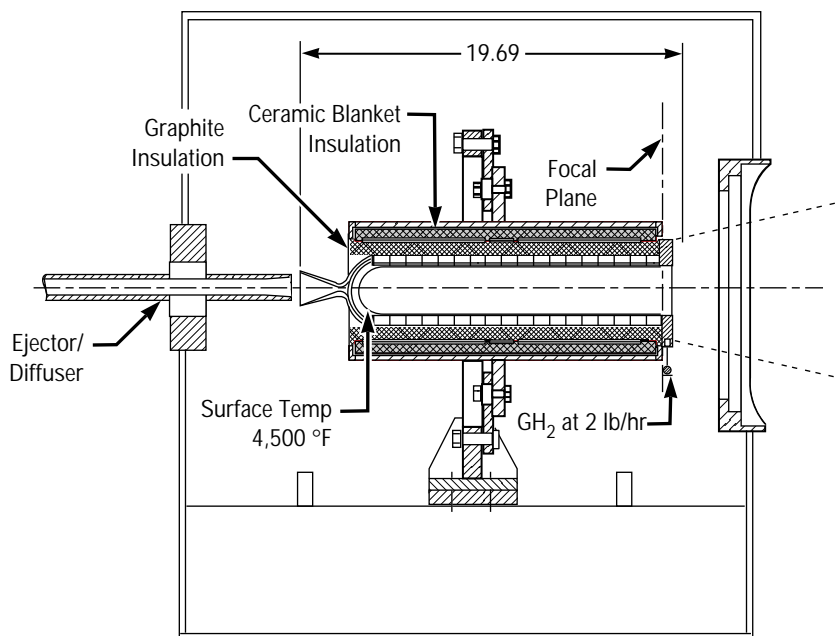


FIGURE 64.—Prototype absorber/thruster mounted in vacuum test chamber.

and then flow to the nozzle.

Fabrication techniques are being explored through the development of a subscale absorber/thruster with a 2.2-Newton thrust. The MSFC vacuum plasma spray facilities have produced several tungsten inner and outer shell samples for an initial test article. Efforts are now in progress to establish a heat-exchanger shape that will assure efficient heat exchange between the inside shell and gaseous hydrogen without excessive pressure losses and fabrication expense or complexity. Flow-passage fabrication experimentation completed to date includes:

- Diamond cut machining: slow and costly; rough cuts—basic shell structure damage likely
- Electrical discharge machining with electrodes: improved cuts

relative to diamond cut, but thermal stresses embrittle and weaken the tungsten; expensive

- Electrical discharge machining with brass wire: best machining process to date; expensive.

**Solar Test Facility:** Construction of the test facility in the East Test Area is planned, and preliminary layouts have been completed. The test facility concept consists of a 47-square-meter heliostat mirror, a 5.5-meter-diameter concentrator, a quartz-windowed vacuum test chamber, gaseous-hydrogen plumbing, and an experiment control system. Accomplishments include fabrication of a prototype concentrator segment (in preparation for fabricating all 144 hexagonal segments), 90-percent completion of concentrator support structure design, fabrication of a

polished 33-centimeter-diameter quartz window, positioning a vacuum pump/test chamber (for thruster testing), and definition of heliostat design/performance requirements.

### Cryogenic Fluid Management

**Subsystem:** MSFC is participating with a consortium in the design of the 2-cubic-meter liquid-hydrogen storage/feed system and performance of the demonstration testing. Elements included are: zero-gravity venting, capillary screen liquid-acquisition device, pressurization/expulsion, and multilayer insulation. Basically, the propellant management subsystem concept consists of utilizing the liquid-acquisition device and thermodynamic vent system to flow 100-percent vapor to the thruster during burn cycles; i.e., the insulation is configured to match the liquid-hydrogen boil-off with the thruster flow rate and mission burn cycle (typically 100 to 200 burns). Accomplishments include preliminary pressure control analyses and definition of test article interfaces in the 6.1-meter-diameter vacuum chamber at test position 300. As an example, pressure-control analyses indicate that tank pressure can be maintained between 310 and 207 kiloNewtons per square meter (45 and 30 pounds per square inch absolute) (requiring engine delivery pressure of approximately 172 kiloNewtons per square meter (25 pounds per square inch absolute) with the assistance of 15 watts of heater power during the coast periods at a fill level of 20 percent.

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